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COMMERCIAL SPACE COMMITTEE

Ohio Aerospace Institute

Cleveland, Ohio

Open Session

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Participants

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Patti Grace Smith, *Chair*

Lon C. Levin
Mr. Stephen S. Oswald
Wilbur C. Trafton, via telecom
Thomas W. Rathjen, *Executive Secretary*
Ms. Shawanda Robinson, *Administrative Officer*

Guests

Ken Davidian, FAA Commercial Space Transportation
Michael Heil, Ohio Aerospace Institute

Stephen Jurczyk, Langley Research Center
Ray Lugo, Glenn Research Center
Ed Mango, Commercial Crew Program Certification, via telephone
Ellen Ochoa, Johnson Space Center
Bryan K. Smith, Glenn Research Center
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Lou Povinelli
Rebecca Sharek
Marc Timm

Thomas Rathjen opened the meeting at 8:15 AM and invited those participating by telephone and WebEx to introduce themselves.

Patti Grace Smith welcomed everyone and introduced Ohio Aerospace Institute Director Michael Heil, who added his welcome. He thanked the Center directors for attending and noted the upcoming SpaceX launch.

Stephen Oswald, the newest committee member, introduced himself.

NASA Glen Research Center Overview

Ray Lugo, Director, GRC

Glenn's mission is to drive research, technology, and systems to advance aviation, enable exploration of the universe, and improve life on Earth. Founded in 1917, GRC has a dual mission in aviation and space. It undertakes no research for research's sake—research is intended to result in new systems and new capabilities. And, they want to be good stewards of the public's trust.

Lewis Field (in Cleveland; 350 acres, 1639 civil servants and 1577 contractors) and Plum Brook Station Test Site (50 miles west in Sandusky; 6500 acres, 13 civil servants and 113 contractors) comprise the Center. To achieve their revised goals, GRC is now interviewing for an Associate Director, has reformulated the Exploration Technology Development and Demonstration (ETDD) Office, and established the Office of Human Capital Management.

About 34% of the center's $641M annual budget is devoted to cross-Agency support, and 13% to space technology. The rest goes to aeronautics (23%), space operations (9%), science (7%), exploration systems (7%), construction (3%), and education (2%). The President's 2013 budget allots an overall $17M increase, but decreases the Center Management and Operations (CMO) and Acquisition Management Office (AMO) budgets by $7M and $2M, respectively. The CMO/AMO reduction implies a 10% reduction across the Center and consequent impacts on its ability to maintain facilities, e.g., hypersonics research has been discontinued within NASA. However, with the significant increase in construction, they are improving horizontal infrastructure so as to avoid emergency repairs, and then replacing buildings and infrastructure.

About two-thirds of the civil service workforce charge their time to a particular mission. The level of full-time civil servants has been declining over the last 15 to 20 years, but should remain stable in the foreseeable future. Eventually they need to take the workforce below the ceiling so they can hire people appropriately skilled to fulfill the revised mission.

Glenn's real competency is in electric propulsion, which enables technologies for both robotic and human space flight. The focus on propulsion, which dates back to National Advisory Committee for Aeronautics (NACA) days, includes both air-breathing and space environments. Other core competencies are: cryogenic fluids management (for both Marshall and Glenn); physical sciences and biomedical technologies in space (e.g., they developed the harness used for astronaut training); fluid physics and combustion (under leadership of the Johnson Space Center); and they are developing the next ion thruster and high-power high-haul thrusters, which should be available for 2016–2017. Other competencies are communications technology and development, e.g., they are the world's leading expert on development of traveling wave and technologies in the V and W band; power, including photovoltaics, batteries, , and energy storage and conversion; and materials and structures for extreme environments, e.g., silicon carbides.

Responses to the Committee's 5 Questions

Question 1. How is the Agency's commercial space strategy perceived at GRC?

GRC's working with commercial operators is important for NASA to expand its space mission, so NASA can focus on deep-space exploration. GRC understands this and has diversified skills that are well-suited to this transition, as it has been for previous transitions. The commercial space community is interested in Glenn's testing and research capabilities, and Glenn can move agilely between programs. Glenn is well positioned to partner with industry to exploit those capabilities.

Question 2. What is GRC doing to promote commercial space?

GRC has been working with a number of companies and has agreements in place. These will be run through a New Business Board of Directors. Glenn is in position to offer theses services to others, as well. They are not competing with other entities that do the same kind of work. For instance, representatives of ATK have met with Glenn representatives over the last few months because they want to use the testing capability at Lewis Field, which has expanded. In fact, Glenn has a regular flow of interested parties who want to work here on projects such as is aerogels development for space applications.

Question 3. What are the Center's plans for transitioning from Shuttle and Constellation programs to the new Agency direction that includes commercial space, and how are those plans progressing?

GRC continues to maintain leadership roles in the Agency program shift while developing GRC's added value to commercial space, e.g., elements of Multi-Purpose Crew Vehicles (MPCV) (including the European Space Agency [ESA] Service Module, which will undergo qualification testing at Plum Brook). It works closely with the Space Launch System (SLS) program to carry over previous expertise (e.g., Thrust Vector Control [TVC], power systems, fairing development). GRC has demonstrated expertise to commercial space providers through work already completed, work currently underway, and numerous areas being explored. (However, NASA's requirements always take precedence over commercial's.) The 7 full-time employees for the Shuttle transitioned over to Orion, SLS, etc. Work is aligned with space-enabling technologies instead of being architecture specific, so the transition has been easy.

Question 4. How is GRC planning to use its facilities for commercial space activities?

A number of Glenn's test facilities offer unique and comprehensive coverage for any commercial space activities, e.g., atmospheric and space environment conditions. Working through a Space Act Agreement (SAA) with the ESA, the B2 facility will be renovated so as to be available to support engine testing. Glenn has worked with the community in the past for aviation capabilities, so the team is accustomed to working in the commercial environment.

Question 5. How is GRC addressing excess capacity issues?
GRC has transitioned its workforce from Constellation without significant issues. All Centers are dealing with excess capacity, e.g., vacuum capabilities, because they can no longer be kept just because they may be needed in 20 years. Glenn is reviewing its capacities for possible needs in the next few years; then will divest themselves of those capacities that no longer fit the mission. Likewise, they are reviewing the facility footprint and closing unneeded buildings.

GRC has 3 concerns: The SAA process is critical for usage of NASA capabilities, but SAA are unique to NASA, and Cooperative Research and Development Agreements (CRADA) could be used. Regardless which tool is used, consistent guidance for all Centers must be applied so agreements can be put in place more quickly. Access to NASA capabilities is key to commercial success, and NASA maintenance of some is critical. To avoid having to build new facilities, we need a way to enable use of existing facilities.

Q&A

- *Ms. Smith* had noticed a healthy tension between Headquarters (HQ) and centers regarding SAAs. She asked whether the Centers know how to write an SAA. *Mr. Lugo* thought Glenn doesn't have as many problems as some Centers, but with ESA, they ran into a problem at the end. Consequently, they reviewed the value-added equation of everyone who has to sign off on the agreement. Knowing why all these people need to sign would be helpful. It is not a question of doing something illegal or unethical; it is just a question of how to do it. *Ellen Ochoa:* Johnson Spaceflight Center (JSC) has done SAAs for 50 years, but now JSC has been doing 4 times the usual number of SAAs, and they have had to scrutinize the procedure depending on who looks at the agreement. The question is who at HQ reviews the agreement, and whether that individual finds a new question. Much progress has been made, but there is still a lot of discussion about what exactly needs to be done. When a commercial company comes to a Center and wants the Center to do certain types of work, the Center must determine whether it would be competing with other commercial entities, and must consider whether the company has proprietary analysis. We need better guidance on what HQ needs and what we need from the company. *Stephen Jurczyk:* At Langley, they have reviewed and revised the SAA procedure; then HQ reviewed it and had the same issues of unique reviews. It just takes time to have the relevant dialogue because of lack of familiarity.

- *Ms. Smith* asked about how to increase partnering between Glenn and commercial industry. *Mr. Lugo* said that he saw the need for nimbleness on both sides. Sometimes the community has to be convinced that the government is accountable for delivering on time. In the long term, industry needs to see value and delivery of performance. Many commercial entities do not know that government capabilities are available to them. Glenn is making agreements, but doing so in the context of making sure they are not competing with commercial

entities is a challenge, and whether the entity is a research or an operational center changes that challenge somewhat.

- *Mr. Oswald* asked about other agreement mechanisms. *Mr. Lugo,* from his non-legal perspective, opined that using a CRADA would be better than using an SAA in instances of true commercialization where more clarity about intellectual property is needed, e.g., fly-wheel technology. An SAA says, essentially, "We'll figure it out as we go along." But, if the commercial company has a large financial risk, they will not be satisfied with that. This does not occur as much in commercial space as it does in commercialization of technologies.

- *Mr. Levin:* The SAA issue seems to encompass 2 issues, i.e., that Centers not compete with commercial entities, and not compete with each other. Has any Center competed with commercial? *Mr. Lugo:* The only instance that came to mind was in commercial work in wind tunnels: In one case someone else could possibly have done it. But, these things are reviewed in great detail, and Glenn offers unique capabilities. Perhaps an international facility could compete, but some companies, e.g., GE, don't want to go outside US borders—they like to work with NASA Centers because they know NASA is bound by law not to divulge trade secrets. *Mr. Jurczyk:* The Chief Council's Office and the Strategic Relationships Office scrutinize these agreements, and there are no known examples of competition. Most work uses test facilities, which tend to be unique to the centers.

- *Ms. Ochoa:* HQ is discussing several SAAs, but before an SAA goes to HQ, JSC has already scrutinized it. The question is defining what you need to show, or what the prospective company needs to provide. These are gray areas. And, JSC is more operations-oriented than some other centers. The situation has gotten a lot better over the past year, but work still needs to be done. *Mr. Lugo:* Sometimes commercial may be able to develop the technology, particularly in analytic areas, but barriers and practicalities would prevent it. If they can't make money why would they get in that line of business? Meanwhile, NASA has invested in tools, training, and technology that private business has no interest in investing in because of the small return on investment. *Mr. Levin* concluded that the Centers need guidelines. But, said *Mr. Lugo*, guidelines are interpreted, e.g., HQ signed off on an umbrella agreement, and Glenn signs off on non-significant parts, but what is "significant"? These are all subject to interpretation.

- *Mr. Levin:* What's wrong with the centers competing with each other? *Mr. Lugo:* NASA has 9 centers of which 2 have core competencies for robotic space. If the centers competed, all centers would have to have robotic space capabilities, which would duplicate effort. We need to figure out how to be complementary rather than competitive. However, some duplicative capability is needed, but to the extent that they do not compete. Non-competition among centers is a benefit to the taxpayer. But, we need the right balance between competition and "co-opetition." We want Glenn's capabilities to enhance the Agency's abilities.

Mr. Jurczyk: The Centers have evolved capabilities and have eliminated competitive ones, e.g., test facilities. They don't want to compete on price, but competition for ideas makes sense, or looking for innovation to break the status quo makes sense. Example of capability of both Langley and Marshall would be structural systems: Langley does basic to mid-level research, and Marshall perfects it so it can be used as a process. *Ms. Ochoa:* The standardized pricing policy is an effort to look at facilities across the Centers to eliminate duplication. At JSC, some test stands have been mothballed, but there was never an issue of competing with other Centers. *Mr. Oswald:* GE's use of the 10X10 wind tunnel makes sense, but he worries about why a contractor would want to partner with government vs another company. *Mr. Lugo* explained that when a company works with a Center, it's not only access to a facility, but also access to NASA researchers.

Mr. Jurczyk: At Langley, collaborations are fully reimbursable, but they are also interested in the data vs the collaborative agreements. They asked Boeing why they were not coming to Langley test facilities and adapted accordingly. Now Boeing comes to Langley (vs Europe or industry) only if they can make a business case to do so. *Mr. Oswald:* For Boeing and GE, NASA is probably not the end-user, although the technology was developed collaboratively. *Mr. Lugo* agreed: No, because we don't build airplanes. But, we are a national repository of knowledge. *Mr. Jurczyk:* The only way we would run afoul would be to pick winners and losers, e.g., selecting Boeing over Lockheed. But, international companies are another issue: there are problems with the existing product line vs creating a new product. Most foreign companies have a US subsidiary, but it still involves the economic competitiveness issue. He recommended immediately initiating a discussion with HQ before drafting an SAA. *Mr. Levin* asked whether companies that go to Europe to do testing were an exception. *Mr. Jurczyk* said no because Europe has a different model. They provide more direct government support than we do. *Mr. Lugo:* The database is increased when they test elsewhere. In Europe, commercial proprietary information may be treated differently.

- *Mr. Oswald* asked about the age of staff members. *Mr. Lugo* said Glenn has an aging workforce whose average age is in the 40s. To change that demographic will require a concerted effort using targeted buy-outs so they can hire appropriately qualified, but younger, people. However, this may also entail a brain drain because the people who would be bought out have experience in managing big programs, although most are now contracted out. *Mr. Jurczyk* noted that Langley also has an aging workforce. They have had buy-outs, but, since the late 1990s, buy-outs have seemed not to be effective. There is pressure to lower the civil servant ceiling, so when people leave, replacements cannot immediately be hired, which limits our ability to re-hire for the right skills. *Mr. Lugo:* Glenn has hired about 150 people since 2007 and can't hire everyone back at entry level; that is not enough to counter the aging demographics. At the same time, while the

workforce is getting older, it is not significantly more diverse. Also there is a poor job market outside NASA, so people tend to stay longer. We need the right strategy to hire appropriate people. Of some 1600 employees, 20% must turn over to change the demographics. And, we need to hire back in areas needed that will better support NASA's changed mission.

- *William Trafton* asked whether Glenn advertises its capabilities. *Mr. Lugo* said ~~"a~~dvertise" is not the right word, but he takes every opportunity to share GRC capabilities, not in print or via other media outlets, but by stating their core capabilities and facilities at every public opportunity—he is doing what he can within the law. He is also sharing information with other centers about these capabilities. The 4 research centers are doing more work collaboratively for that. Any time Mr. Lugo meets with a commercial entity, he suggests a follow-up call or visit if he sees an opportunity for another center. *Ms. Ochoa* said it is the same for the human space flight centers, all of which have formed some kind of new office for strategic opportunities.

NASA Langley Research Center Overview

Stephen Jurczyk, Deputy Director, LaRC

Founded in 1917 as the first civil aeronautical research lab, Langley Research Center's (LaRC's) work spans fundamental research to mission development and operation; they lead in systems innovation for achieving on-demand air mobility. Their mission to provide game-changing innovations complements the Agency's mission. They will need to collaborate with the Federal Aviation Administration (FAA) to fulfill the vision of making space accessible to everyone, perhaps via virtual access vs actual access. Another vision is understanding climate change by flying instruments to measure weather and climate; this function has been transferred to the Weather Service.

Of the Center's $831M annual budget, $27M is devoted to external business. Cross-Agency support programs are distributed: 44% for Aeronautics, 28% Science, 15% Space Technology, 12% Human Exploration, and 1% Education. Their work is mainly Earth science, chemistry, and dynamics, e.g., they measure aerosols and ozone in the upper stratosphere. Their Lidar system was used to develop 2-dimensional profiles of clouds and their properties, the biggest variability in climate change now.

Of some 2600 employees, 1900 are civil servants and 1700 are contractors, and there are about 250 students. Old buildings are expensive to maintain, and new ones are much more efficient. Therefore, Langley is updating its master plan to encompass ~~"N~~ewtown," 5 new buildings in addition to other renovated buildings. The first building has been completed, and ground was broken for the second. They are also closing facilities no longer needed.

Langley is organized into product units—Aeronautics Research, Science, Exploration & Space Operations, Flight Projects, Strategic Relationships, Ground Facilities & Testing,

etc.—and then mission support services—Safety & Mission Assurance, Systems Management, Office of Procurement, Chief Counsel, etc. Langley's core competencies are: aerosciences research for flight in all atmospheres; aerospace systems analysis (tools to do early systems engineering, e.g., support for Helios, and different vehicle concepts for different architectures); entry, descent, and landing (Langley does trajectory simulation and flight dynamics and works in collaboration with the Jet Propulsion Laboratory [JPL] and Ames Research Center, e.g., the August 5 Mars landing mission, which is twice as large as the rovers); characterization of all atmospheres; and aerospace structural and material concepts (e.g., nitro vs carbon nanotubes, large deployable structures, inflatable habitats for in-space vehicles). Aerosciences is by far the largest competency. Earth science capabilities include research and analysis and archiving data.

Langley's facilities constitute national assets required to meet the needs of the Agency, the Department of Defense (DoD), and industry. Major test facilities are: the 14 X 22foot Subsonic Wind Tunnel, National Transonic Facility (NTF; the cryogenic wind tunnel); LaRC Unitary Plan Wind Tunnel (for supersonic speed range); Aerothermodynamic Complex, Flight Simulation Facility, 20-foot Vertical Spin Tunnel, Transonic Dynamics Tunnel, and 8-foot High Temperature Tunnel.

Systems development and R&D are needed by the Air Force. Human Exploration and Operations includes work on the Space Launch System, Orion's Launch Abort System, Commercial Crew and Cargo, Composites, Extravehicular Activity, and Radiation Protection. Langley has collaborated with Ames on a thermal protection system (TPS). Advanced Exploration Systems entails in-house work for risk reduction for humans. Langley built systems and engineering for Ares I-X, and for Orion's Pad Abort 1 test, they built the crew module simulator. Such fabrication alliance has expanded across all Centers.

Space Technology Development focuses on lightweight materials and structures, such as large deployable structures (in collaboration with Glenn), and inflatable aero-shells to give a large surface area and enable delivery of large payloads to Mars. They will test the Morpheus vehicle and landing instrumentation on Mars Science Laboratory (MSL). A Materials International Space Station Experiment-X (MISSE-X) has been aboard the Space Station for many years; the new one will go on Dragon with SpaceX as the first foray in externally attached payloads post-Shuttle. Radiation Protection involves transport codes, computational codes, and shielding concepts, e.g., electrostatic gossamer structures and boron nitride nanotube materials.

Commercial Space Support (undertaken at Ames) supports the SpaceX Dragon to do images of reentry, abort loads analysis, and wind tunnel testing. Langley's biggest commercial space collaboration is with Sierra Nevada Corporation's (SNC's) Dream Chaser.

Key Questions
Question 1. How is the Agency's commercial space strategy perceived at LaRC?

This is not new to Langley. LaRC doesn't build aircraft, but provides supporting systems, so people moved quickly from supporting Constellation, Orion, and the Shuttle to supporting core space in general. LaRC has embraced the Commercial Space strategy and strives to support this new initiative. In essence, it has shifted from an operational mode back to research and development.

Question 2. What is LaRC doing to promote commercial space?
LaRC did minor reorganization to create the Commercial Space Projects Office. They visited Sierra Nevada and SpaceX (but, as yet, not Boeing) to make them aware of LaRC's capabilities. They also take advantage of conferences and other meetings to increase their visibility.

Question 3. What are the Center's plans for transitioning from Shuttle and Constellation programs to the new Agency direction that includes commercial space, and how are those plans progressing?
Langley's transition from the Shuttle to Commercial Space was not a huge transition because what they are doing for Commercial Space the same kinds of things they did for the Shuttle. They have transitioned from Orion to Orion Multi-Purpose Crew Vehicle (MPCV), and from Ares to the Space Launch System (SLS). (They were not as involved in the Ares flight test program just because of its scale.)

Question 4. How is LaRC addressing excess capacity issues?
The workforce has not been an issue; they have transitioned from Shuttle/Constellation to Commercial Space/SLS/Orion MPCV/Space Technology with no excess capacity issues. The issue is most significant for the wind tunnels, which operate on a cost-recovery basis. The customer base has eroded over the last few decades because the country, as a whole, is developing far fewer aircraft. We do a lot of configuration screening instead of actual testing, which results in a shortfall of $15M to $20M each year. We will work with commercial and Aeronautics Test Program (ATP) to close that gap. Already, we have gone to block operations, which reduces capacity, but the staff has decreased over the years.

Question 5. Do you have any concerns or issues with transitioning to the Agency's commercial space strategy?
The commercial space companies need a stable NASA budget, to avoid unplanned changes and maintain their development schedules. We are working through problems with the SAA approval process, which needs to be streamlined to meet commercial space companies' schedules. The Unitary Plan Wind Tunnel will by mothballed in July 2012; SLS is the only one that tests there, but they can do that at Glenn, Ames, or maybe the Air Force. The same wind tunnel is preferred for repeat tests, so this wind tunnel may be mothballed later. The real uses are SLS and commercial space, which are not enough business to cover the cost of the facility.

Q&A

- *Ms. Smith* asked about the agreement mechanism used for the partnership with Draper. *Mr. Jurczyk* explained that Langley subcontracted to Draper via an SAA.

Mr. Oswald asked whether it was based on a deliverable, but with no firm fixed price. *Mr. Jurczyk:* Yes, the SAA required a deliverable, so they have deliverables and a schedule according to which each part must be delivered. This was done by assessing the budget and cost risks, and budgeting reserves accordingly. If the company burns through the reserves, we work with them. As with any other project, we try to look ahead and take pro-active measures.

- *Ms. Smith* asked about Langley's contribution at Wallops.
  Mr. Jurczyk: They used Langley's expertise to be sure they wouldn't damage the pad during launch.

- *Mr. Levin* asked about the confluence of work on space weather. *Mr. Jurczyk:* For climate monitoring, the instruments will fly on the Joint Polar Satellite System (JPSS), with the Weather Service overseeing development of the instruments (which will be developed on contract). The 7 instruments will be flown on 4 different space vehicles. Langley provides expertise and oversees instrument development for long-term measurement. The National Oceanic and Atmospheric Administration (NOAA) fully reimburses the costs.

- *Mr. Oswald:* This would be a subset of overhead costs. How do you book proposals within the government—are they a subset of general and administrative (G&A) costs? *Mr. Jurczyk:* They are a subset within G&A. They have a call every year to allocate money to both civil service hours and dollars. Most goes to science activities, e.g., Earth Science Pathfinder and proposals for vehicles 1 and 2; most bid and proposal (B&P) costs go there.

- *Mr. Trafton:* When tracking international programs, how do you handle International Traffic in Arms Regulations (ITAR) issues? *Mr. Jurczyk:* Langley has an ITAR program and is open to dialogue with appropriate mission directorates, as well as the Office of General Counsel. They also have a person on the program side that has regular telecons on international relations.

NASA Johnson Space Center Overview

Ellen Ochoa, Deputy Director, JSC

The Committee's 5 key questions are addressed throughout the presentation. Johnson Space Center (JSC) patterned its 6 goals on NASA's mission and vision, providing and applying its preeminent capabilities to development. From this, 4 overarching goals emerged: lead human exploration; lead internationally; excel in leadership, management, and innovation; and expand relevance to life on Earth.

To implement these overarching goals, JSC devised additional strategic goals. Assembly of the International Space Station (ISS) is now complete. As the first strategic goal, JSC wants to make sure that its exploitation is the cornerstone of human exploration and wants to maintain its international lead. Many technological development programs have

emerged, e.g., Advanced Exploration Systems (AES), and many have extended the duration of life support systems.

As the second goal, we want to develop and expand ties throughout the technical world so teams and people can collaborate with their counterparts. JSC has extensive experience with international agreements with countries and companies. They guided the development of the Global Exploration Roadmap (beyond Lower Earth Orbit [LEO]) and understand where partnerships might advantageous as they develop.

Additional strategic goals—innovative technologies, and aeronautics research for societal benefit—are more about how JSC does things, its business management practices. JSC negotiates SAAs, as well as open innovations via challenges on commercial Web sites for prize money. It is not necessarily about developing all technology themselves, but finding out where this knowledge exists. JSC has devoted much effort to inclusion and innovation of both academic and commercial partners. How human space flight affects people on Earth implies education and communication.

As a strategic implementation plan has been developed, each directorate and all supervisors have met and discussed strategies and reviewed goals, strategies, and success factors. The Commercial Space Strategy is enabling commercialization of LEO. JSC works closely with commercial companies, supporting commercial crew and developing additional commercial opportunities in space, such as satellite servicing, orbital debris removal, expanded access, and R&D platforms. JSC works with commercial space companies in 2 major ways: through the program offices, e.g., Commercial Orbital Transportation Services (COTS) and the Commercial Crew & Cargo Program (C3PO). COTS works closely with the ISS program office, so everyone is clear about what needs to be demonstrated and when that needs to be done. In the Commercial Crew Program (CCP), JSC is actively participating on Partner Integration Teams. Partnerships through Reimbursable and Non-Reimbursable SAAs provide direct support to companies and permit access to unique JSC facilities and capabilities.

JSC manages the Innovative Lunar Demonstrations Data (ILDD) contract to purchase data associated with industry efforts to design and demonstrate end-to-end robotic lunar landing missions..

Institutionally, JSC has active reimbursable SAAs with Blue Origin, SNC, SpaceX, Boeing, ULA, Scaled Composites, Bigelow, and ATK. For example, they trained SpaceX employees in low-oxygen environments; they have done thruster testing; interface and operations development; engineering and test services support; technical services for spacecraft design; pyrovalve testing; expandable space structures and materials; and technical services for spacecraft operations.

Other agencies, such as FAA, are critical to the success of the commercial space sector to address medical concerns and risk mitigation for human health and performance, especially for companies interested in space tourism. JSC expertise is relevant to all

markets of commercial space. It now works with both FAA and the Air Force Research Laboratory (AFRL).

JSC is meeting commercial space needs through robotics specialized to crew assistance or automation to another environment of human space flight. JSC has tried to ensure that prospective partners understand JSC's capabilities via, e.g., a Web site and a conference co-sponsored by the American Institute for Aeronautics and Astronautics (AIAA). Commercial space can benefit from JSC expertise in damage detection and repair resolution for re-entry after 6 months or so in space, radiation shielding and counter-measures, component failure analysis and materials testing. Counterfeit parts are becoming problematic in the space industry as they become more difficult to detect, but JSC has a facility that specializes in counterfeit detection.

The White Sands Test Facility focuses on hypervelocity impact (relevant to space debris), Composite Overwrapped Pressure Vessels (COPV) testing, thermal vacuum chambers, anthropometry and biomechanics to test crew members in cockpit situations (including some 27 measurements), and modeling and design in a simulation facility. Many of these facilities are not large, maybe only a room or part of a room in a facility, but the expertise available makes the facility unique. The Energy Systems test Area allows them to test pyrovalves. White Sands is also conducting tests on nitrous oxide (N_2O_2) for propulsion.

JSC has expertise and capabilities important throughout the life cycle of a spacecraft. They are working with Ad Astra on a magnetoplasma rocket, and have an active partnership with Bigelow for inflatable habitat technology as they continue to work on their own inflatable program. JSC partnered with Armadillo Aeropspace (an emerging company) for in-space propulsion to test a liquid oxygen/methane (LOX/CH4) engine in combination with automatic landing hazard-avoidance technology. They are doing more testing at JSC and then moving the product to KSC, e.g., hypervelocity impact testing for MicroMeteoroid and Orbital Debris (MMOD) and MMOD risk assessments. Other capabilities are launch imagery screening and analysis; providing engineering support for Sierra Nevada Corporation (SNC) for structural loads and capture analysis associated with final approach and docking at ISS; analyzing physiological or crew performance data related to design of the partner's spacecraft, human factors, and human system integration; and providing imagery and lunar surface knowledge support to assess potential visits to past lunar landing sites by Google X-Prize competitors.

JSC is supporting Commercial Crew partners Boeing, Sierra Nevada, and ATK, e.g., definition of mission operations approaches and systems requirements, operations insight for ongoing design of vehicle subsystems, and information on NASA's systems operations, training, planning, and process development. Overall, partnerships must be affordable, cost effective, and sustainable. JSC seeks partnerships where it makes sense to support strategies. They want to expand thinking beyond the aerospace community to medicine and transportation, e.g., the R2 robot was developed in collaboration with General Motors (GM) whose goal was to prevent repetitive motion injuries. They developed a process that could be done by humans and by robots (not 2 separate systems). These are similar technologies, but with different end uses. JSC wants to

provide solutions for technologies we need for future mission without thinking we have to develop them ourselves, which is not affordable. To do this, JSC engages intermediaries, e.g., non-profits, which can act as clearing houses.

JSC's culture is evolving to one that reaches out. The Strategic Opportunities and Partnership Development (SOPD) Office was formed to facilitate this. It is a paradigm change within the Center—they are interested in cultivating relationships and opening doors in a more customer-focused environment. JSC has far more contractors than civil servants, and plans to use the same ratio to support commercial space.

An example of excess capacity was the neutral buoyancy lab. ISS still needs it for training, but not nearly so much as during the assembly phase. NASA is required to keep the lab, but it is now operated by a contractor, Raytheon. Raytheon is incentivized to find partners to use it, e.g., off-shore oil workers. This facility is almost tailor-made for the oil industry's new requirements. In addition to the pool, they need test conductors, safety procedures, hyperbaric sensors, and emergency responses. JSC wants to expand and do contingency training (the oil companies need certified training); mission operations people support this facility. White Sands has always depended on non-NASA customers and has the capability to reach out to commercial space companies. ISS crew and cargo servicing will remain the backbone of JSC's support.

Challenges include: improving the SAA review and approval process, although progress has been made within JSC; balancing resources between programmatic work and the increasing demands of JSC's partnership portfolio; and transforming JSC's business culture to one that is reliable, progressive, innovation-centered, and easy to work with.

Q&A

- *Ms. Smith:* How much does NIH utilize JSC capabilities? *Ms. Ochoa:* NIH was an initial partner, but she didn't know the exact number of projects or dollars involved. Health is one area in which much progress has been made that can be explained to the public, e.g., the study of *Salmonella,* which became more virulent in space (for unknown reasons), so it was easier to develop a vaccine. She did not know how much the pharmaceutical industry participated.

- *Ms. Smith:* Does JSC collaborate with The Federal Communications Commission (FCC)? *Ms. Ochoa:* The orbital debris program focuses on measuring and protecting spacecraft, and they work closely with DoD, but NASA has started to do more. JSC is funded to think about ways to deal with removal of orbital debris, recognizing that larger pieces can break up into many smaller pieces.

- *Mr. Levin:* A number of companies talk about wanting to work in space. Does NASA have a way to facilitate serious dialogues with serious contenders? *Ms. Ochoa:* That is a role for NASA HQ, but the Office of Strategy Formulation is beginning to think through these matters. JSC has a lot of knowledge about risk to spacecraft (shielding etc.). *Mr. Lugo:* Electric propulsion is an excellent technology for these things, so the first question for HQ is, does NASA have a

role in orbital debris removal? NASA has some capabilities, and might enable commercialization of this. *Mr. Levin* noted the limited budget, which would limit the role to thinking about it with no active role to actually do it.

- *Mr. Oswald:* By commercializing space transport and the Shuttle, some thought costs could be reduced by a factor of 2. Clearly government adds a lot of cost. How do you curb government's appetite to control? *Ms. Ochoa:* Much can be done when defining high-level objectives, which are much less prescriptive than they used to be. Government gives leeway to industry. We say they must have some the ability to recover from failures, and then they must tell us how they will do that. We now have less paperwork in costing information and we require contractors to provide much less information on cost details. This should reduce development costs. We are also backing off things on contracts that are now seen to be unnecessary.

- *Mr. Oswald:* How do you decide what government's role is in clearing a failure? Who makes launch decisions? *Ms. Ochoa:* We will certify for a commercial crew; then we will not be involved, including looking at failures on launch day, etc. We will understand their process and systems and then leave it to them to do it. On commercial cargo, we are not involved at all until they come within a certain proximity to ISS. All we are saying is that they met certain safety requirements that would allow them go get within a certain proximity of ISS. SpaceX has asked us for certain expertise. *Mr. Rathjen:* NASA will certainly have some go/no-go authority for NASA crew. *Ms. Smith:* When the count-down occurs, those with a vested interest have the opportunity to weigh in. *Ms. Ochoa:* Performance-based requirements can be a hard term. We evolved them based on the belief that there's more than one way to get an item done. We didn't take a hands-off approach, but allowed the performance to speak to the way things should be done.

- *Mr. Trafton:* Judging from last month's ~~–6~~0 Minutes" program, and testimony on the Hill, there is a lot of concern about crew safety with commercial launches. Some of this chatter could be reduced if NASA would formally state that we are not putting an astronaut in conditions we deem unsafe. *Mr. Jurczyk:* Brian O'Connor and others wrote requirements in a way commercial would find useful. *Mr. Oswald:* The definition of certification will be important, and it could be hugely expensive. *Ms. Ochoa:* We want to understand what the back-ups are for human safety. We tell them what they must ensure, but not how to do it.

- *Ms. Smith* asked about qualifying an astronaut for commercial space flight to the ISS. *Ms. Ochoa* said information is available on various health screens a prospective astronaut would have to pass. JSC has a long history of working with other space agencies, and all must agree that the person in question qualifies.

- *Mr. Oswald:* Will commercial crew be flown out of a particular spaceflight center? *Ms. Ochoa:* That depends on the company. They were not focusing on

the operations part initially, and JSC has expertise in this area that's underutilized at the moment. An Orion test flight is scheduled for 2014, unmanned in 2017, and manned in 2021. *Ms. Smith* noted that SpaceX is considering owning its own launch facility.

- *Mr. Trafton:* What innovative business management practices, other than SAAs, are being undertaken? *Ms. Ochoa:* More use is being made of open innovation strategies, mostly in human health and performance. (All were done from scratch in the past.) Lately JSC has been trying to understand what capabilities exist in industry that might be applied to space, e.g., a paint company technology that could be repurposed to measure silver biocide in the water on ISS. Other examples may be found via 3 or 4 challenges with an open innovation posted on the Incentive Web site. For 3 JSC challenges, for which prizes were awarded, they received thousands of responses from 65 countries, e.g., predicting space weather, and methods to preserve food in space. Through this they found people they would never have found in any other way. This process differs from SAAs and from what JSC used to do.

- *Mr. Levin* wondered whether, in trying to create a business culture, JSC has people experienced in business? *Ms. Ochoa* admitted that they have few. One person has worked at NASA, JSC, and Lockheed, and they have gotten some business support. Although there is no funding for this, they have received Center Management and Operations (CMO) encouragement. In 2 years, JSC has reduced its workforce by 4000 people (about 200 were civil servants). They need to reduce more, which will give them the capability to hire people with these qualifications. They don't have a business development group.

- *Ms. Smith* asked whether NASA has the means to accept an executive on loan. *Ms. Ochoa:* Certain capabilities are implicit in intergovernmental agreements, such as the Intergovernmental Personnel Act (IPA), to bring in other people. *Mr. Lugo:* IPA can also bring in academics, but he didn't know about third party financing. Glenn has formulated a New Business Office, but that was done with civil servants. First we must make sure technology is available. Then, they need new business engineers, who know about finances, etc., not new business closers. Glenn has over 100 lines of research, many of which have dual purposes, and they have learned from experience that they have to be totally versed in technology, so a company will license a technology from the Center. Commercialization and particularly dual-use commercialization is paramount, e.g., battery use in space and in automotive use—the space environment can increase knowledge in an environment that results in less costly mistakes.

  Mr. Jurczyk: At Langley they hired 3 people with business development experience, and they used to have a group doing technology commercialization. But the budget situation challenges these activities, and now they use outside groups (e.g., Research Triangle Group). *Ms. Ochoa:* The final thing we all face is that as we try to expand partnerships, it requires more time from lawyers and

others at the same time the workforce is being reduced. *Mr. Levin:* This is a fundamental issue of trying to cut back across the board at a time of transition when certain skill areas must be increased. Is this expertise available to you at HQ? *Ms. Ochoa:* There are no standard business skills at the Agency.

Mr. Lugo: But, it may not be good to put this issue at HQ because one size does not fit all. Glenn is trying to figure out how to grow reimbursable business enough so they can tax those reimbursable dollars and build a nucleus. But 3% to 5% is about as much as you can tax, so long term, it's getting enough reimbursable business to infuse the monies back into doing all these things. We need to merge NASA dollars with the private dollars. *Ms. Ochoa:* HQ is facing the same problems the centers are. They are looking at a lot more SAAs with fewer people to review them. *Mr. Oswald:* An element of trust is missing. We need good business development people, but few of them want to work for the government.

Commercial Crew Program Certification Status Briefing

Ed Mango, Program Manager, CCP [*via telecom*]

Commercial Crew Program (CCP) goals are to facilitate development of commercial crew space transportation capability, achieving safe, reliable, and cost-effective access to and from LEO and the ISS. Strategic goals for the Commercial Crew integrated Capability (CCiCap) phase are to advance multiple integrated crew transportation systems (CTS) to crewed orbital demonstrations by mid-decade, commercial provider investment, and affordable development costs leading to cost-effective access to LEO.

Because of budgetary flexibility and options and for certification, CCiCap is divided into 2 phases, the base period (August 2012 to May 2014), followed by an optional phase culminating in orbital crewed flight demonstrations. The optional phase may be accomplished either with an optimum funding profile or funding fixed at $400M per year per partner. Goals for the base period are: to achieve detailed integrated design of CTS; demonstrate a process to analyze, quantify, and understand risks; risk reduction activities; and criteria and plan for industry certification of a crewed demonstration flight. Optional milestone goals are to complete test activities leading to industry certification, and the final milestone being an orbital crewed demonstration flight. Safety goals are to: foster a strong safety culture in commercial space flight and demonstrate safety processes that include healthy tension, strong internal checks and balances, and value-added independent review.

At the moment, CCP is reviewing the CCiCAP proposals, but we want to offer multiple awards. The follow-on certification phase has been under review since CCiCAP inception. The certification phase will probably use Federal Aviation Regulations (FAR) contracting to meet NASA requirements. The overall strategy began in FY2010–2011 with Blue Origin, Boeing, Paragon, Sierra Nevada, and ULA developing technologies, and continued in 2011-2012 with Boeing, SpaceX, Sierra Nevada, Blue Origin, ULA, ATK, and Excalibur developing element designs. By FY2012–2014, CCiCap will

develop an integrated capability; and from FY2013 to FY2017, certification and initial ISS missions will be accomplished.

The content and scope of certification planning is evolving. Several near-term certification activities are underway to improve planning, and our "1100 series" requirements documents have been publicized for reference. The CCP is now reviewing and updating verification statements for these requirements, developing program certification processes and the CTS certification plan. The CCP Acquisition Planning Team is developing and assessing options that enable NASA certification and ISS services, e.g., requirements in the 1100 series state that the astronaut must have egress from the vehicle other than aborting. That is being developed by the Space Office, Ground Office, and Vehicle groups. This will answer the question, can you get people out before there is a hazard in the crew module? The Technical Review Board will go through some 100 verification statements between now and summer. They released the 1100 series in November. Some were more open to negotiation with industry as to how requirements might be met, e.g., understand and manage the risks of aborting. Ultimately, we want to be able to measure any partner against the same criteria.

CCP is undergoing internal certification processes so the program can define how it will work with the partner, i.e., how many review cycles, and criteria are to be met. The Acquisition Planning Team is a third of the puzzle for certification. They are now updating CCP verification statements, and developing program certification processes and acquisition planning options so all will come together in an integrated path to certification planning and Agency approval.

In sum, the CCP has laid out a near-term path to continuing integrated design and has begun detailed planning leading to an integrated path for a comprehensive certification process. The bottom line of that overall success of the CCP (both for government and industry) is predicated on a comprehensive and streamlined certification process. Our partners are making good progress under the CCDev2 agreements, which will continue through the summer.

Q&A

- *Mr. Oswald:* We need to figure out how to do NASA certification so the risk is reasonable; at the same time, many within NASA grew up doing Shuttle and Station activities. How will you manage a combined team to provide the right kind of risk, but keep it affordable? *Mr. Mango:* From a programmatic process standpoint, that is my #1 concern. Some things are in place, such as Insight Teams. CCDev2 revealed that many of the partners had unworkable milestones, and some of these partners have sought NASA help based on their past experience. We are very much working with engineering and safety, so we can focus on a core team of engineers who will not rotate frequently. Now we have begun to train another set of people to think this way. Previously approved certification plans will be used; but NASA doesn't have to certify that the data are correct. Oversight will focus on how data match a requirement and whether a test did what it was supposed to do. The learning process started in CCDev2, which

will intensify during CCiCAP. The partners don't want NASA in control, but they do whatever NASA asks them to do.

- *Mr. Trafton*: One way they're changing the culture is through a hand-picked team in Mr. Mango's program office that will look at new ways to do business. Also, they want to keep the office small, and they are levying only level 2 requirements (200 or 300). Lessons learned are being leveraged and incorporated.

- *Mr. Oswald:* This will make a tougher leadership job of winning hearts and minds of the teams. *Brent Jett:* The technical certification team is already starting to deal with these kinds of issues. They're looking at what endorsements NASA will sign for certification. To manage this, NASA must establish expectations at the beginning, and then use the contract structure to prevent lower-level people from complicating the issue.

- *Mr. Trafton:* The media (~~"6~~0 Minutes," interviews, the evening news) make negative statements about commercial crew. NASA should come forward with a positive statement about not putting astronauts on unsafe vehicles. *Mr. Mango:* We're not going to fly NASA crew on any vehicle we don't think is safe, regardless whether we meet milestones. *Mr. Jett:* Administrator Bolden has also made this statement, as well as that our requirements will be the same for the commercial system as for the NASA system. But, these statements have not extinguished those doubts. *Mr. Mango:* Our 1100 series documents have been circulated, and they list requirements that must be met. The whole effort for certification results from NASA's requirement to put astronauts only on safe vehicles. If this committee has ideas for making this message moreclear, CCP would welcome them.

- *Ms. Smith* asked about the areas for streamlining certification. *Mr. Mango:* Level-2 requirements are the only thing NASA will sign off on—not level 3, 4, or 5—and that's huge streamlining. All specifications have been listed, which is also streamlining. We want partners to bring their own methods for meeting these requirements. E.g., some partners have different thoughts for composites, and we need to be open to that. When we write verification requirements in the 1100 serious update, which will come out in a couple of months, they are points of departure. *Mr. Jett:* Add to that the distinction between the design standard ~~"m~~eets or exceeds" vs ~~"m~~eets." This recognizes that NASA may not be on cutting edge of composite technology and there may be better ways.

- *Ms. Smith:* Assuming there will not be 3 partners in CCiCap, if you down-select from 2 to 1 partner, then what? *Mr. Mango:* We need competition. The cost for 1 is greater than for 2 or 3. Optional milestones give a better return than expected. Instead of putting in the X, they put in X + Y because they saw that there was potential for the future. Competition yields a better price and a more innovative product. *Ms. Smith* asked about the criteria for down-selection. *Mr. Mango* had no specific criteria for that; they have the goals and how many are selected is left to

the selection authorities. We know we want more than 1, but we are not committed to a particular number.

- *Ms. Smith* raised the issue of having a finite amount of money. *Mr. Mango:* In CCDev2, awards were given for varying amounts, so they already started to make some conscious decisions about what they could afford. But no algorithm for that has been devised. *Mr. Oswald* feared they might be sacrificing life-cycle costs. *Mr. Mango:* That would mean total costs would go up. A restricted budget means we have to look at how we incentivize competition within whatever profile Congress gives us. We are still very much in the proposal evaluation period on CCiCAP.

- *Mr. Oswald* thought they would have to spend time making the case for more than 1 partner. *Mr. Mango* agreed that they are trying to do that. This Committee can help spread the word that competition is in everyone's interest. The cost of 1 is probably at least double what it would be for multiples. *Mr. Jett:* This is true for this particular program, but we cannot generalize as to strategy. This program is unique, yet competition allows us to leverage unique strategies. By having more than 1 partner, we can do some unique things. *Phil McAlister* noted that NASA is committed to this, which is exemplified by changes to the SAA procedure, so we are not forced to select 1, even though we may be forced to select fewer than desired. This goes back to the culture change question.

Office of Safety and Mission Assurance (OSMA) Briefing

Terrence Wilcutt, Chief, OSMA [*via telecom*]

Both the Commercial Orbital Transportation Services (COTS) program and CCP are in good shape, but they have particular concerns. This Committee is interested in the Agency's transition, and there is no reason it can't work. Of most concern is the engineering and medical standards and requirements: the later you find out that a company does not meet these requirements, the greater the expense and the more extensive schedule interruption you incur. That will put huge stakes on people to find problems, although, they can't make requirements immediately.

Mark Emminger, for Commercial Cargo, said the only requirement the COTS partners have to meet is for whatever is taken to ISS. One concerned drag-through lines, which were then removed. Companies have to meet NASA requirements before they can approach the ISS, and we want to make sure companies are not cutting corners to meet the schedule.

Scott Johnson, Commercial Crew Program, added: The process of certifying a commercial service is a huge challenge. The safety community is wrestling with their future insight and oversight role, and trying to pull together the right approach. They will be working closely with the program and Mr. Wilcutt's office during which differences

of opinion will emerge and be resolved. Resources are available to assist providers. Mitigation strategies are being designed to cope with the many issues and concerns.

Q&A

- *Mr. Oswald:* How commercial is COTS? If cargo goes in the water, do taxpayers pay? *Mr. Emminger:* We are paying for a space company to deliver cargo to ISS; they have to get their own insurance against mishap. Cargo is class D (low value), so if something happens and it disappears, it won't endanger any mission. Total reliability for crew survival requirements are specified in the 1000 series documentation.

- *Ms. Smith:* Where are you in FAA licensing? *Mr. Ermminger:* For COTS it's already in place. *Mr. Johnson* added: Mr. Gerstenmaier (NASA's Associate Administrator for Human Exploration and Operations) wants them to start working with FAA. The partners would take care of their own launches with FAA observing, but that's all under discussion. It is not a question of if, but when.

Introduction to the Federal Aviation Administration Center of Excellence for Commercial Space Transportation & NASA Participation Options

Ken Davidian, Director of Research, FAA

Mr. Davidian spent 16 years at Glenn Research Center, Lewis Field, in Space Propulsion and understands Glenn's perspective. At the Federal Aviation Administration (FAA), air traffic control is the main function, and R&D is a fraction of the discretionary budget. FAA's Office of Commercial Space Transportation (CST) mission intends to regulate the commercial space transportation industry, only to the extent necessary, to ensure compliance with US international obligations and to protect the public health and safety, safety of property, and national security and foreign policy interest of the US. It also aims to encourage, facilitate, and promote commercial space launches and re-entries.

The Centers of Excellence (COE) were started 13 years ago (Omnibus Budget Reconciliation Act of 1990), funded at about $1M per year, as a 10-year partnership of academia, industry, and government to create a world-class consortium. Its goals are research, training, and outreach/Science, Technology, Engineering, and Mathematics (STEM), which will address current and future challenges for commercial space. Projects are openly competed, and selected by the FAA Administrator. A unique feature is the requirement that every dollar be matched by academia or the government.

Currently, there are 9 primary COE CST member universities: Stanford University, University of Colorado, New Mexico State University, New Mexico Institute of Mining and Technology, University of Texas Medical Branch, University of Florida, Florida State University, University of Central Florida, Florida Institute of Technology. This format provides an acquisition instrument to do research elsewhere.

The Office of the Chief Technologist published *Research Roadmap Report* (December 2011), which identifies 4 major research areas: space traffic management and operations; space transportation operations, technologies, and payloads; human spaceflight; and space transportation industry viability. Scott Hubbard headed this roadmap team and has worked with that office to find the FAA overlaps. Some 24 tasks were funded the first year. NASA can provide insight, participation, oversight, and sponsorship.

In summary, COE is a unique R&D acquisition instrument with broad scope, global reach, and a 1:1 matching requirement for all US government funds. It maximizes common interests of overlapping mission areas, furthers multiple FAA–US government partnering operations, and offers a full spectrum of benefits and alignment with the National Strategic Plan. Explanatory publications can be downloaded.

Q&A

- *Mr. Levin:* When do you analyze COE CST research? Is this a ~~–c~~heerleading exercise" or a rigorous analysis? *Mr. Davidian:* Being in charge of markets, he has been seeking academically based works that apply to industry. Much aerospace decision-making is based on analysis without benefit of these perspectives. He wants to base decisions on the best academic work available, e.g., Clayton Christensen, Michael Porter, Brian Nalborough, Eric Brandenburg. Orbital has medium to low resemblance to business markets; suborbital has medium to high resemblance to business markets.

- *Ms. Smith* asked about funding. *Mr. Davidian* said funding from the Air Traffic Organization (ATO) is notional at this point. Joseph Wilson, in charge of the R&D Executive Board, thought $10M was needed to start the program. They are trying to get into the R&D budget because they cannot function long term with $1M.

- *Ms. Smith* asked about integration of space launch vehicles with the National Airspace System. *Mr. Davidian:* NextGen has been pulled out of ATO, so it has a separate research chunk that links to air traffic and space traffic management. They are trying to get into the budget line items. Each box in research areas has a program attached. Processes were created within AST to get started (a third of the discretionary budget).

- *Mr. Oswald asked if space transportation is included. Mr. Davidian* answered yes. . The focus on research has a bit of a different twist than at NASA, e.g., thermal protection is considered from the perspective of convenience and cost vs safety and reliability. FAA and NASA need to undertake much more discussion. The other two-thirds of the discretionary budget goes to regulatory decision-making. They are now funding 24 graduate students. He invited everyone to come to Socorro, New Mexico, for the November launch. *Mr. Oswald* observed that requirements for a launch from the Cape would differ from one from New Mexico. *Mr. Davidian:* Absolutely, e.g., the need to close flight paths around

Thanksgiving are minimal in New Mexico. Ames is trying to use Stanford through the COE, but has encountered legal obstacles.

Public Comments and Closing Remarks

No comments.

Adjournment

- *Ms. Smith* thanked Glenn Research Center for hosting this meeting, and *Mr. Davidian* for his presentation. The last round of center meetings will be held this summer and fall. After 2 meetings, the committee is beginning to see topics for recommendations.

- *Mr. Levin* thought the meetings had been very high quality and well run. All centers seem to be going in the direction Administrator Bolden wants them to.

- *Mr. Oswald* agreed that it had been a great meeting, and he appreciated other members' patience in allowing him to catch up.

Ms. Smith adjourned the meeting at 2:45pm.